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PB-254 053

LAKE WAWASEE, KOSCIUSKO COUNTY, INDIANA

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PREPARED FOR
NATIONAL ENVIRONMENTAL RESEARCH CENTER

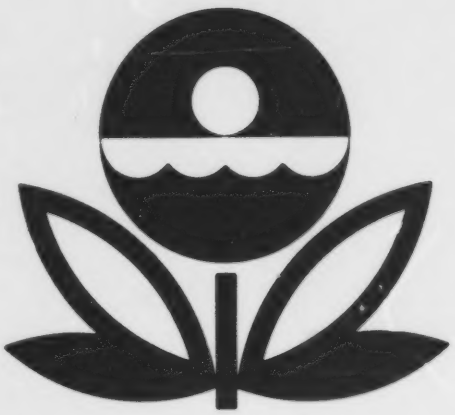
MARCH 1976

177054

PB 254 053

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT
ON
LAKE WAWASEE
KOSCIUSKO COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 344

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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SPRINGFIELD, VA. 22161

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB254053
4. TITLE AND SUBTITLE Report on Report on Lake Wawasee, Kosciusko County, Indiana		5. REPORT DATE Prepared March, 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 344
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		41
	20. SECURITY CLASS *(This page)*	22. PRICE
		$4.00

EPA Form 2220-1 (9-73)

REPORT

ON

LAKE WAWASEE

KOSCIUSKO COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 344

WITH THE COOPERATION OF THE

INDIANA STATE BOARD OF HEALTH

AND THE

INDIANA NATIONAL GUARD

MARCH, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

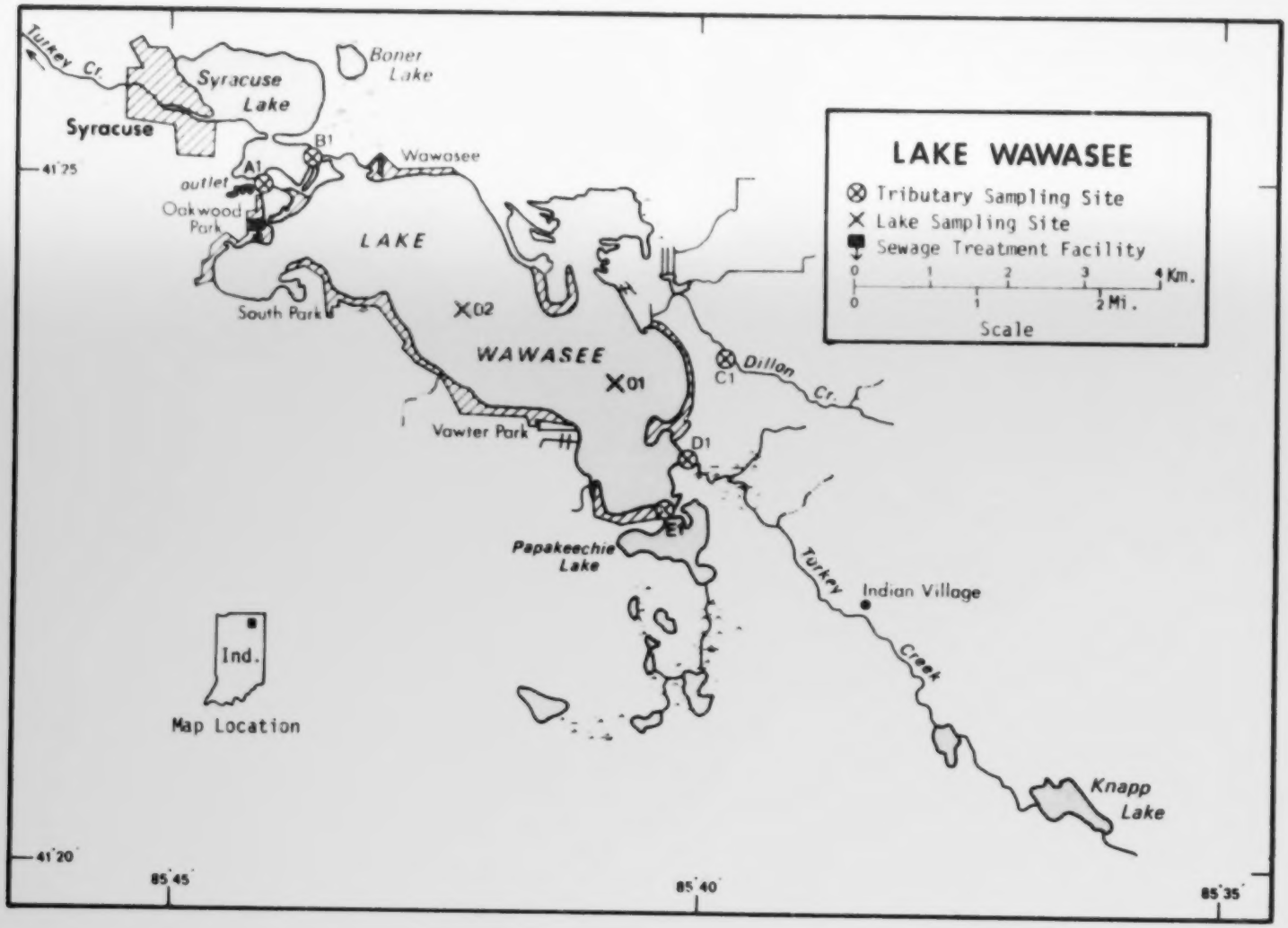
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


LAKE WAWASEE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 4 Km.
0 1 2 Mi.
Scale
Turkey Cr.
Syracuse Lake
Syracuse
Boner Lake
B1
Wawasee
A1
outlet
Oakwood Park
LAKE
41°25'
South Park
X02
WAWASEE
X01
C1
Dillon Cr.
Vawter Park
D1
E1
Papakeechie Lake
Turkey Creek
Indian Village
Knapp Lake
Ind.
Map Location
41°20'
85°45'
85°40'
85°35'

LAKE WAWASEE

STORET NO. 1836

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Wawasee is mesotrophic. Of the 27 Indiana lakes sampled in 1973, it ranked first in overall trophic quality when compared using a combination of six parameters*. One of the lakes had less and one had the same median total phosphorus, none had less but two had the same median dissolved phosphorus, four had less median inorganic nitrogen, three had less mean chlorophyll a, and only one had greater mean Secchi disc transparency. Near-depletion of dissolved oxygen occurred in the hypolimnion at both sampling stations in August.

Survey limnologists noted submerged and emergent macrophytes in the shallows and along some of the shoreline near station 1 in October.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Wawasee was phosphorus limited at the time the sample was taken (05/03/73). The lake data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--The point-source phosphorus contribution amounted to an estimated 19% of the total input to Lake Wawasee

* See Appendix A.

during the sampling year. The wastewater treatment facility of the Methodist Church at Oakwood Park contributed an estimated 9.1%, and lakeshore septic tanks were estimated to have contributed 9.9%.

The present phosphorus loading rate of 0.11 $g/m^2/yr$ is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 12). Any phosphorus removal program initiated essentially would be for the purpose of maintaining the present quality of the lake.

The relatively long mean hydraulic retention time of 3.5 years should be considered as further shoreline development occurs. If a wastewater treatment plant is established to serve lakeshore residences, treatment should include phosphorus removal. This has been recommended in another report on this lake (Gifford et al., 1971).

2. Non-point sources--Non-point sources accounted for 81% of the total phosphorus load to the lake. Turkey Creek contributed 32.9%, Dillon Creek contributed 5.1%, and Papakeechie Lake outlet contributed 9.1% of the load. Ungaged tributaries were estimated to have contributed 18.2% of the load.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 12.38 kilometers^2.
2. Mean depth: 6.7 meters.
3. Maximum depth: 23.5 meters.
4. Volume: 82.946 x 10^6 m^3.
5. Mean hydraulic retention time: 3.5 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Turkey Creek	41.2	0.38
Dillon Creek	5.7	0.05
Papakeechie Lake outlet	14.2	0.13
Minor tributaries & immediate drainage -	20.7	0.20
Totals	81.8	0.76

2. Outlet -

Outlet Channels A-1	78.7	0.64
B-1	15.5	0.12
Totals	94.2**	0.76**

C. Precipitation***:

1. Year of sampling: 79.7 centimeters.
2. Mean annual: 88.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Wawasee was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 14.3 meters at station 1 and 11.3 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WAWASEE LAKE
STORET CODE 1836

PARAMETER	1ST SAMPLING (5/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 4/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/15/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	13.1 - 13.4	13.3	13.3	15.1 - 25.4	22.2	23.4	17.6 - 18.0	17.8	17.8
DISS OXY (MG/L)	9.3 - 9.7	9.5	9.6	0.4 - 9.4	6.2	8.3	7.0 - 8.0	7.5	7.4
CNDCTVY (MCROMO)	410. - 420.	414.	410.	328. - 342.	332.	330.	313. - 317.	315.	315.
PH (STAND UNITS)	8.3 - 8.3	8.3	8.3	7.4 - 8.7	8.3	8.5	8.1 - 8.2	8.1	8.1
TOT ALK (MG/L)	145. - 148.	146.	146.	112. - 158.	124.	115.	120. - 127.	124.	125.
TOT P (MG/L)	0.005 - 0.014	0.007	0.005	0.010 - 0.014	0.012	0.012	0.009 - 0.015	0.012	0.012
ORTHO P (MG/L)	0.002 - 0.006	0.004	0.003	0.002 - 0.003	0.002	0.002	0.004 - 0.007	0.005	0.005
NO2+NO3 (MG/L)	0.500 - 0.570	0.532	0.530	0.070 - 0.230	0.108	0.100	0.040 - 0.090	0.064	0.060
AMMONIA (MG/L)	0.040 - 0.050	0.046	0.050	0.060 - 0.460	0.143	0.090	0.120 - 0.150	0.130	0.130
KJEL N (MG/L)	0.500 - 0.700	0.575	0.600	0.700 - 1.000	0.811	0.800	0.700 - 1.200	0.900	0.900
INORG N (MG/L)	0.540 - 0.620	0.579	0.580	0.130 - 0.560	0.251	0.190	0.170 - 0.230	0.194	0.180
TOTAL N (MG/L)	1.000 - 1.270	1.107	1.105	0.790 - 1.100	0.919	0.900	0.760 - 1.250	0.964	0.950
CHLRPYL A (UG/L)	3.4 - 3.7	3.5	3.5	6.9 - 7.9	7.4	7.4	3.9 - 4.2	4.0	4.0
SECCHI (METERS)	2.8 - 3.7	3.2	3.2	****** -**********			3.7 - 3.7	3.7	3.7

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/03/73	1. Oocystis sp.	380
	2. Cyclotella sp.	371
	3. Melosira sp.	361
	4. Flagellates	361
	5. Fragilaria sp.	234
	Other genera	351
	Total	2,058
08/04/73	1. Microcystis sp.	835
	2. Gomphonema sp.	519
	3. Melosira sp.	230
	4. Cryptomonas sp.	173
	5. Cyclotella sp.	115
	Other genera	318
	Total	2,190
10/15/73	1. Flagellates	407
	2. Melosira sp.	319
	3. Fragilaria sp.	231
	4. Gomphosphaeria sp.	77
	5. Microcystis sp.	77
	Other genera	210
	Total	1,321

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/03/73	1	3.7
	2	3.4
08/04/73	1	7.9
	2	6.9
10/15/73	1	4.2
	2	3.9

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.550	0.1
0.050 P	0.055	0.550	13.0
0.050 P + 1.0 N	0.055	1.550	20.9
1.0 N	0.005	1.550	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Wawasee was low at the time the sample was collected (05/03/73). Also, a significant increase in yield when phosphorus alone was added indicates that this body of water was limited by phosphorus at that time. Note that the addition of nitrogen alone resulted in a yield no different than that of the control.

The lake data also indicate phosphorus limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 33/1 or greater at all sampling stations and times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station C-1, in kg/km^2/year, and multiplying by the ZZ area in km^2.

The operator of the Oakwood Park United Methodist Church wastewater treatment plant provided monthly effluent samples but did not provide flow data. Therefore, nutrient loads were estimated at 0.567 kg P and 3.401 kg N/capita/year; and flows were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

All estimated phosphorus loads were reduced by 50% to adjust for a phosphate detergent ban which has been in effect in Indiana since January, 1972.

A. Waste Sources:

1. Known domestic -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Oakwood Park Methodist Church*	219	act. sludge	82.9	Lake Wawasee

2. Known industrial - None

* Hollar, 1973 (population seasonally adjusted based on 125 people served per year and 500 people or more served during the summer).

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Turkey Creek	450	32.9
Dillon Creek	70	5.1
Papakeechie Lake outlet	125	9.1
b. Minor tributaries & immediate drainage (non-point load) -	250	18.2
c. Known domestic STP's -		
Oakwood Park Methodist Church	125	9.1
d. Septic tanks* -	135	9.9
e. Known industrial - None	-	-
f. Direct precipitation** -	215	15.7
Total	1,370	100.0

2. Outputs -

Outlet Channels	
A-1	460
B-1	90
Total	550

3. Net annual P accumulation - 820 kg.

* Estimate based on 948 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Turkey Creek	41,175	38.1
Dillon Creek	8,125	7.5
Papakeechie Lake outlet	4,980	4.6
b. Minor tributaries & immediate drainage (non-point load) -	29,500	27.3
c. Known domestic STP's -		
Oakwood Park Methodist Church	745	0.7
d. Septic tanks* -	10,105	9.4
e. Known industrial - None	-	-
f. Direct precipitation** -	13,365	12.4
Total	107,995	100.0

2. Outputs -

Outlet Channels	
A-1	34,010
B-1	7,350
Total	41,360

3. Net annual N accumulation - 66,635 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Turkey Creek	11	999
Dillon Creek	12	1,425
Papakeechie Lake outlet	9	351

* Estimate based on 948 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.11	0.07	8.7	5.4

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Wawasee:	
"Dangerous" (eutrophic loading)	0.28
"Permissible" (oligotrophic loading)	0.14

V. LITERATURE REVIEWED

Gifford, Cameron E., Michael Melampy, William Bishop, and Margaret Hollinger, 1971. A summary of a chemical and bacteriological survey of lakes Wawasee and Syracuse. Admin. Comm., Lakes Study Fund, Syracuse.

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Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATARACT LAKE	0.056	1.600	466.667	10.744	15.600	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.800	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.867	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	464.833	47.480	14.800	0.017
1849	MOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.018	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.445	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MOWSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	65 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (2.)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1836 WAWASEE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 95.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1836A1	78.7	0.96	1.13	1.60	1.46	0.97	0.74	0.45	0.16	0.15	0.16	0.39	0.71	0.74
183681	15.5	0.178	0.221	0.320	0.292	0.190	0.147	0.088	0.026	0.027	0.027	0.076	0.144	0.144
1836C1	5.7	0.062	0.079	0.119	0.108	0.068	0.054	0.031	0.008	0.009	0.009	0.028	0.054	0.052
1836D1	41.2	0.490	0.589	0.844	0.767	0.507	0.385	0.232	0.079	0.076	0.079	0.201	0.374	0.384
1836E1	14.2	0.161	0.204	0.294	0.269	0.173	0.133	0.079	0.024	0.024	0.025	0.071	0.133	0.132
1836ZZ	22.0	0.255	0.311	0.453	0.413	0.269	0.207	0.125	0.040	0.040	0.040	0.108	0.204	0.205

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 95.6
SUM OF SUB-DRAINAGE AREAS = 177.4

TOTAL FLOW IN = 19.91
TOTAL FLOW OUT = 0.0

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1836A1	6	73	1.189	9	1.529				
	7	73	0.538	14	0.340				
	8	73	0.510	11	0.283				
	9	73	0.164	15	0.136				
	10	73	0.133	13	0.125				
	11	73	0.283	11	0.119				
	12	73	1.019	15	0.510				
	1	74	2.718	19	0.963				
	2	74	1.699	2	1.982	16	0.623		
	3	74	2.605	2	1.161	15	1.699		
	4	74	1.189	13	1.246				
	5	74	0.963	19	1.359				
183681	6	73	0.227	9	0.283				
	7	73	0.108	14	0.062				
	8	73	0.096	11	0.054				
	9	73	0.031	15	0.025				
	10	73	0.025	13	0.023				
	11	73	0.057	11	0.023				
	12	73	0.204	15	0.099				
	1	74	0.538	19	0.193				
	2	74	0.311	2	0.396	16	0.119		
	3	74	0.510	2	0.227	15	0.340		
	4	74	0.227	13	0.244				
	5	74	0.190	19	0.269				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1836 WAWASEE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1836C1	6	73	0.085	9	0.110				
	7	73	0.020	14	0.003				
	8	73	0.011	11	0.003				
	9	73	0.0	15	0.0				
	10	73	0.001	13	0.0				
	11	73	0.003	11	0.0				
	12	73	0.071	15	0.017				
	1	74	0.198	19	0.071				
	2	74	0.119	2	0.144	16	0.025		
	3	74	0.187	2	0.085	15	0.127		
	4	74	0.085	13	0.082				
	5	74	0.071	19	0.099				
1836D1	6	73	0.595	9	0.793				
	7	73	0.283	14	0.170				
	8	73	0.255	11	0.144				
	9	73	0.082	15	0.071				
	10	73	0.068	13	0.065				
	11	73	0.153	11	0.062				
	12	73	0.538	15	0.266				
	1	74	1.416	19	0.510				
	2	74	0.850	2	1.019	16	0.311		
	3	74	1.359	2	0.595	15	0.906		
	4	74	0.623	13	0.651				
	5	74	0.510	19	0.708				
1836E1	6	73	0.207	9	0.261				
	7	73	0.065	14	0.023				
	8	73	0.051	11	0.017				
	9	73	0.006	15	0.006				
	10	73	0.004	13	0.003				
	11	73	0.019	11	0.003				
	12	73	0.181	15	0.0				
	1	74	0.481	19	0.170				
	2	74	0.283	2	0.340	16	0.079		
	3	74	0.453	2	0.204	15	0.311		
	4	74	0.207	13	0.221				
	5	74	0.170	19	0.210				
1836ZZ	6	73	0.311	9	0.396				
	7	73	0.153	14	0.088				
	8	73	0.136	11	0.076				
	9	73	0.045	15	0.037				
	10	73	0.037	13	0.031				
	11	73	0.079	11	0.031				
	12	73	0.283	15	0.142				
	1	74	0.765	19	0.272				
	2	74	0.453	2	0.566	16	0.170		
	3	74	0.736	2	0.311	15	0.481		
	4	74	0.311	13	0.340				
	5	74	0.269	19	0.368				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

183601
41 23 34.0 085 40 45.0 3
WAWASEE LAKE
18085 INDIANA

083291

11EPALES 2111202
0043 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	16 00	0000	13.3		110	420	8.30	147	0.050	0.700	0.570	0.005
	16 00	0004	13.3	9.6		410	8.30	148	0.050	0.600	0.560	0.003
	16 00	0028	13.2	9.7		420	8.30	147	0.050	0.500	0.550	0.006
	16 00	0040	13.1	9.6		420	8.30	147	0.040	0.600	0.560	0.004
73/08/04	15 00	0000	25.4			330	8.60	115	0.090	0.800	0.110	0.002
	15 00	0005	25.2	9.4		334	8.70	113	0.080	0.700	0.090	0.002
	15 00	0015	23.4	8.3		330	8.50	114	0.090	0.800	0.100	0.002
	15 00	0025	22.7	6.7		332	8.10	118	0.080	0.800	0.070	0.002
	15 00	0040	15.1	0.4		330	7.40	158	0.460	1.000	0.100	0.003
73/10/15	10 15	0000	17.9	8.0	144	314	8.20	120	0.130	1.200	0.050	0.007
	10 15	0015	17.8	8.0		315	8.20	121	0.130	1.000	0.080	0.005
	10 15	0025	17.8	7.8		315	8.10	123	0.120	0.800	0.050	0.005
	10 15	0035	17.6	7.2		316	8.10	127	0.140	1.000	0.040	0.005
	10 15	0047	17.6	7.2		317	8.10	126	0.150	0.700	0.080	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	16 00	0000	0.009	3.7
	16 00	0004	0.014	
	16 00	0028	0.006	
	16 00	0040	0.005	
73/08/04	15 00	0000	0.012	7.9
	15 00	0005	0.012	
	15 00	0015	0.013	
	15 00	0025	0.014	
	15 00	0040	0.014	
73/10/15	10 15	0000	0.012	4.2
	10 15	0015	0.012	
	10 15	0025	0.012	
	10 15	0035	0.014	
	10 15	0047	0.015	

STORET RETRIEVAL DATE 76/03/30

183602
41 24 03.0 085 42 14.0 3
WAWASEE LAKE
18085 INDIANA

083291

11EPALES 2111202
0032 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	16 45	0000	13.4		144	410	8.30	145	0.050	0.600	0.510	0.004
	16 45	0004	13.3	9.6		410	8.30	145	0.040	0.500	0.510	0.003
	16 45	0015	13.3	9.4		410	8.30	145	0.040	0.500	0.500	0.002
	16 45	0030	13.3	9.3		410	8.30	145	0.050	0.600	0.500	0.002
73/08/04	15 30	0000	25.1			342	8.60	116	0.090	0.800	0.100	0.002
	15 30	0005	24.5	9.4		333	8.60	113	0.100	0.800	0.100	0.003
	15 30	0015	23.3	8.7		328	8.50	112	0.060	0.800	0.070	0.002
	15 30	0035	15.1	0.6		330	7.40	153	0.240	0.800	0.230	0.002K
73/10/15	10 50	0000	18.0	7.6	144	315	8.20	125	0.130	1.000	0.890	0.006
	10 50	0020	17.8	7.0		314	8.10	125	0.120	0.700	0.060	0.004
	10 50	0037	17.7	7.2		313	8.10	126	0.120	0.800	0.060	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	16 45	0000	0.005	3.4
	16 45	0004	0.005	
	16 45	0015	0.005	
	16 45	0030	0.008	
73/08/04	15 30	0000	0.010	6.9
	15 30	0005	0.012	
	15 30	0015	0.012	
	15 30	0035	0.013	
73/10/15	10 50	0000	0.013	3.9
	10 50	0020	0.009	
	10 50	0037	0.010	

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/30

1836A1
41 24 55.0 085 44 07.0 4
OUTLET CHANNEL
18 7.5 LAKE WAWASEE
0/WAWASEE LAKE 083291
1240 N RD BRDG AT W EDGE OF LAKE ISLAND
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	09 45		0.260	1.400	0.050	0.005K	0.015
73/07/14	10 35		0.026	3.800	0.250	0.007	0.030
73/08/11	10 45		0.016	1.150	0.048	0.006	0.045
73/09/15	09 45		0.012	0.970	0.036	0.007	0.020
73/10/13	10 55		0.014	0.840	0.030	0.005K	0.025
73/11/11	10 00		0.042	0.500	0.033	0.005K	0.015
73/12/15	10 00		0.136	0.600	0.052	0.005K	0.010
74/01/19	15 00		0.160	0.400	0.064	0.005K	0.010
74/02/02	09 45		0.152	0.800	0.065	0.005	0.005
74/02/16	10 15		0.208	1.400	0.075	0.005K	0.010
74/03/02			0.168	1.700	0.095	0.015	0.035
74/03/15	17 00		0.430	0.800	0.035	0.005K	0.010
74/04/13	10 30		0.450	2.000	0.055	0.010	0.030
74/05/19	13 00		0.352	1.100	0.060	0.005	0.015

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

183681
41 25 05.0 085 43 40.0 4
OUTLET CHANNEL
18 7.5 LAKE WAWASEE
O/WAWASEE LAKE 083291
1240 N RD BRDG AT N EDGE OF LAKE ISLAND
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	10 00		0.180	1.540	0.078	0.005K	0.025
73/07/14	10 55		0.042	3.100	0.110	0.005K	0.025
73/08/11	11 00		0.020	2.400	0.077	0.005K	0.025
73/09/15	09 50		0.010K	0.870	0.016	0.005K	0.020
73/10/13	11 00		0.019	1.050	0.040	0.005K	0.025
73/11/11	10 05		0.031	1.050	0.060	0.005K	0.025
73/12/15	10 15		0.128	0.600	0.072	0.008	0.015
74/01/19	15 10		0.148	0.500	0.084	0.005K	0.010
74/02/02	10 25		0.184	0.700	0.087	0.005	0.015
74/02/16	10 30		0.176	0.800	0.080	0.005K	0.010
74/03/02			0.144	1.200	0.105	0.010	0.025
74/03/15	17 10		0.390	1.200	0.035	0.005K	0.015
74/04/13	10 40		0.420	4.000	0.115	0.010	0.025
74/05/19	12 30		0.288	0.600	0.045	0.010	0.017

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1836C1
41 23 40.0 085 39 40.0 4
DILLON CREEK
18 7.5 LAKE WAWASEE
T/WAWASEE LAKE 083291
1100 N RD BRDG .4 MI SE OF ENCHANTED HIL
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	10 35		7.200	1.380	0.039	0.018	0.025
73/07/14	11 15		0.132	1.600	0.210	0.030	0.085
73/08/11	11 05		0.110	0.770	0.200	0.033	0.075
73/12/15	10 30		0.052	0.300	0.084	0.008	0.015
74/01/19	15 20		6.720	0.500	0.040	0.048	0.070
74/02/02	10 20		7.560	0.400	0.025	0.020	0.030
74/02/16	10 40		6.200	0.400	0.020	0.025	0.030
74/03/02	11 40		4.200	0.500	0.015	0.010	0.030
74/03/15	15 30		4.800	0.500	0.010	0.030	0.050
74/04/13	11 00		4.000	2.800	0.095	0.015	0.030
74/05/19	12 46		4.900	0.500	0.035	0.015	0.035

STORET RETRIEVAL DATE 76/03/30

183601
41 22 55.0 085 40 00.0 4
TURKEY CREEK
18 7.5 LAKE WAWASEE
I/WAWASEE LAKE 083291
HWY 13A BRDG .3 MI OF WAWASEE FISH HATCH
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	10 45		1.420	2.000	0.040	0.008	0.035
73/07/14	11 25		1.060	1.380	0.080	0.019	0.045
73/08/11	11 15		0.990	0.990	0.060	0.026	0.052
73/09/15	10 30		1.400	1.600	0.089	0.015	0.035
73/10/13	11 25		1.120	0.960	0.066	0.010	0.042
73/11/11	10 30		1.900	1.550	0.140	0.005K	0.010
73/12/15	10 45		1.440	0.800	0.100	0.012	0.030
74/01/19	15 30		2.640	0.700	0.084	0.016	0.040
74/02/02	10 30		3.100	0.900	0.085	0.020	0.050
74/02/16	10 45		3.200	1.200	0.065	0.015	0.040
74/03/02	11 50		2.940	2.200	0.210	0.020	0.055
74/03/15	17 35		2.500	1.900	0.025	0.010	0.030
74/04/13	11 15		2.100	1.400	0.050	0.005	0.025
74/05/19	13 15		1.500	1.100	0.035	0.015	0.025

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1836E1
41 22 35.0 085 40 15.0 4
PAPAKEECHIE LK OUTLET
18 7.5 LAKE WAWASEE
T/WAWASEE LAKE 083291
HWY 13A BRDG NEAR WAWASEE ST FISH HATCH
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	11 00		0.024	2.000	0.105	0.012	0.020
73/07/14	11 40		0.042	1.150	0.098	0.009	0.030
73/08/11	11 20		0.050	0.615	0.066	0.011	0.025
73/09/15	10 40		0.025	1.300	0.063	0.010	0.045
73/10/13	11 30		0.075	1.380	0.072	0.010	0.045
73/11/11	10 45		0.032	0.350	0.105	0.005K	0.020
74/01/19	15 40		0.076	0.500	0.032	0.005K	0.025
74/02/02	10 30		0.064	0.500	0.025	0.005K	0.015
74/02/16	11 00		0.068	1.200	0.025	0.005K	0.045
74/03/02	11 55		0.124	0.700	0.075	0.015	0.035
74/03/15	17 40		0.104	0.700	0.010	0.005K	0.025
74/04/13	11 30		0.012	1.700	0.032	0.005	0.030
74/05/19	13 27		0.029	0.700	0.035	0.010	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1836XA EA1836XA P000125
41 24 35.0 085 44 07.0 4
OAKWOOD PARK
18 7.5 LK WAWASEE
T/LAKE WAWASEE 083291
CROMWELL DITCH
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/21	11	00							
CP(T)-			22.000	13.800	0.006	1.315	2.020		
73/06/21	16	00							
73/07/19	11	00							
CP(T)-			15.000	0.730	0.100	2.900	3.450		
73/07/19	16	00							
73/08/27	11	00							
CP(T)-					0.088	2.720	3.200		
73/08/27	16	00							
73/09/21	11	00							
CP(T)-			23.400	2.400	0.068	1.900	2.100		
73/09/21	16	00							
73/10/22	11	00							
CP(T)-			17.400	0.300	0.005K	1.540	2.300		
73/10/22	16	00							
73/11/21	11	00							
CP(T)-			13.400	0.500	0.026	0.530	0.640		
73/11/21	16	00							
73/12/26	11	00							
CP(T)-			8.200	0.500K	0.010K	0.290	0.330		
73/12/26	16	00							
74/01/21	11	00							
CP(T)-			10.100	1.000K	0.096	0.240	0.407		
74/01/21	16	00							
74/02/19	11	00							
CP(T)-			9.800	1.000K	0.120	0.110	0.280		
74/02/19	16	00							
74/03/19	11	00							
CP(T)-			5.400	1.000K	0.087	0.130	0.280		
74/03/19	16	00							
74/04/22	11	00							
CP(T)-			12.000	3.800	0.050K	0.290	0.510		
74/04/22	16	00							
74/05/22	11	00							
CP(T)-			14.000	1.000	0.050K	0.500	0.820		
74/05/22	16	00							

K VALUE KNOWN TO BE
LESS THAN INDICATED